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(54) **STRUCTURE OF PHOTOELECTRIC CONVERSION ASSEMBLY HAVING A CIRCUIT BOARD EMBEDDED WITHIN THE CONCAVE PORTION OF AN OPTICAL BENCH**

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H04B 10/25 (2013.01)

(52) **U.S. Cl.**
CPC ***H04B 10/2504*** (2013.01)

(58) **Field of Classification Search**
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USPC 250/551, 227.11
See application file for complete search history.

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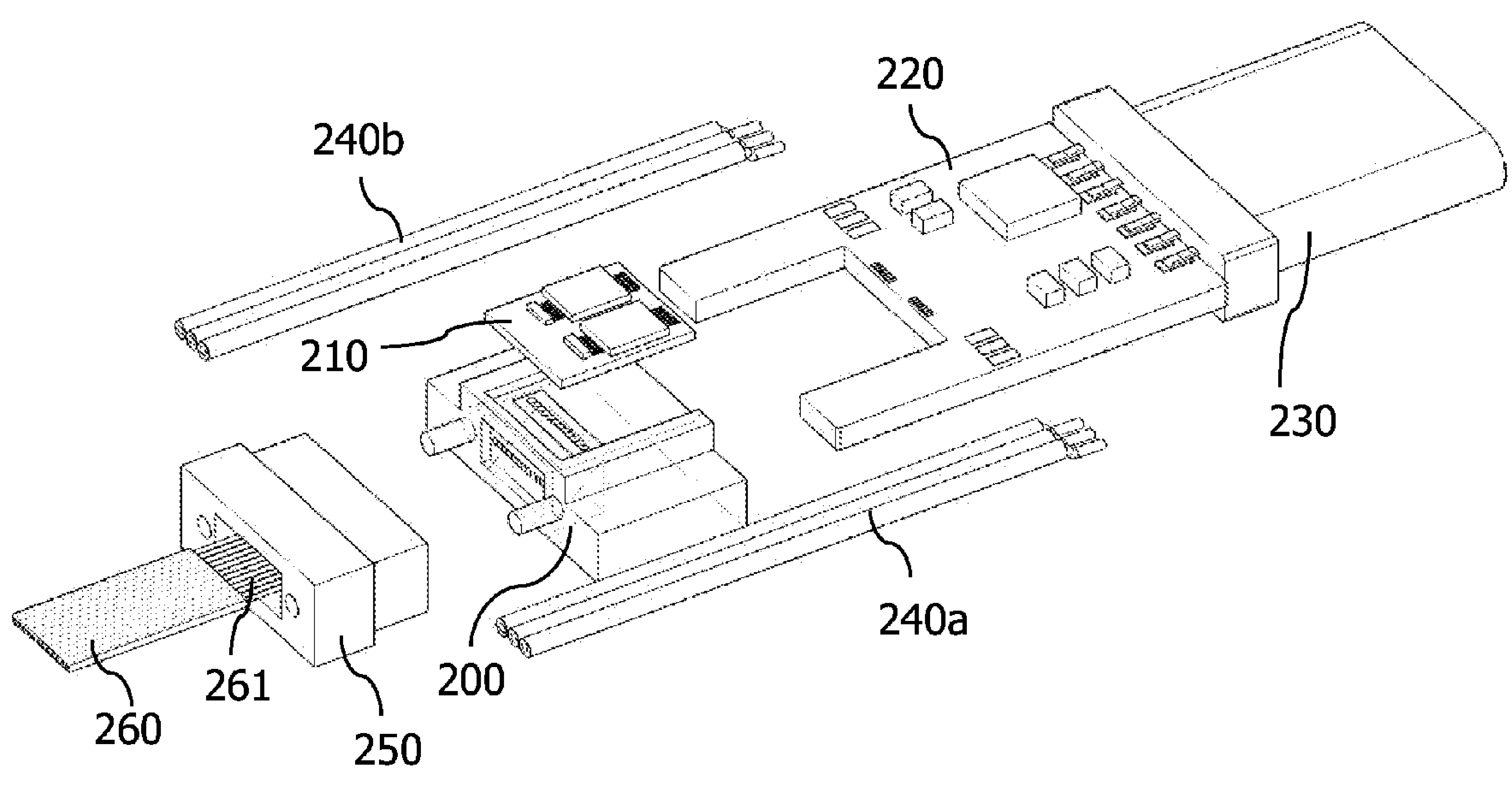
(57) **ABSTRACT**

A photoelectric conversion assembly is proposed. The photoelectric conversion module comprises three parts, photoelectric conversion module, a printed circuit board (PCB) and a hybrid cable. The photoelectric conversion module comprises an interposer, at least one optical element configured on the interposer, and an optical bench for the printed circuit board and the interposer configured thereon. Electrical wires are used for coupling to the printed circuit board. An optical ferrule is used for engaging with the photoelectric conversion module and an optical fiber component. A plug is used for electrically connecting the printed circuit board. A first lens array is configured under the interposer. A mirror is configured under the first lens array. A second lens array is configured left side of the mirror.

20 Claims, 9 Drawing Sheets



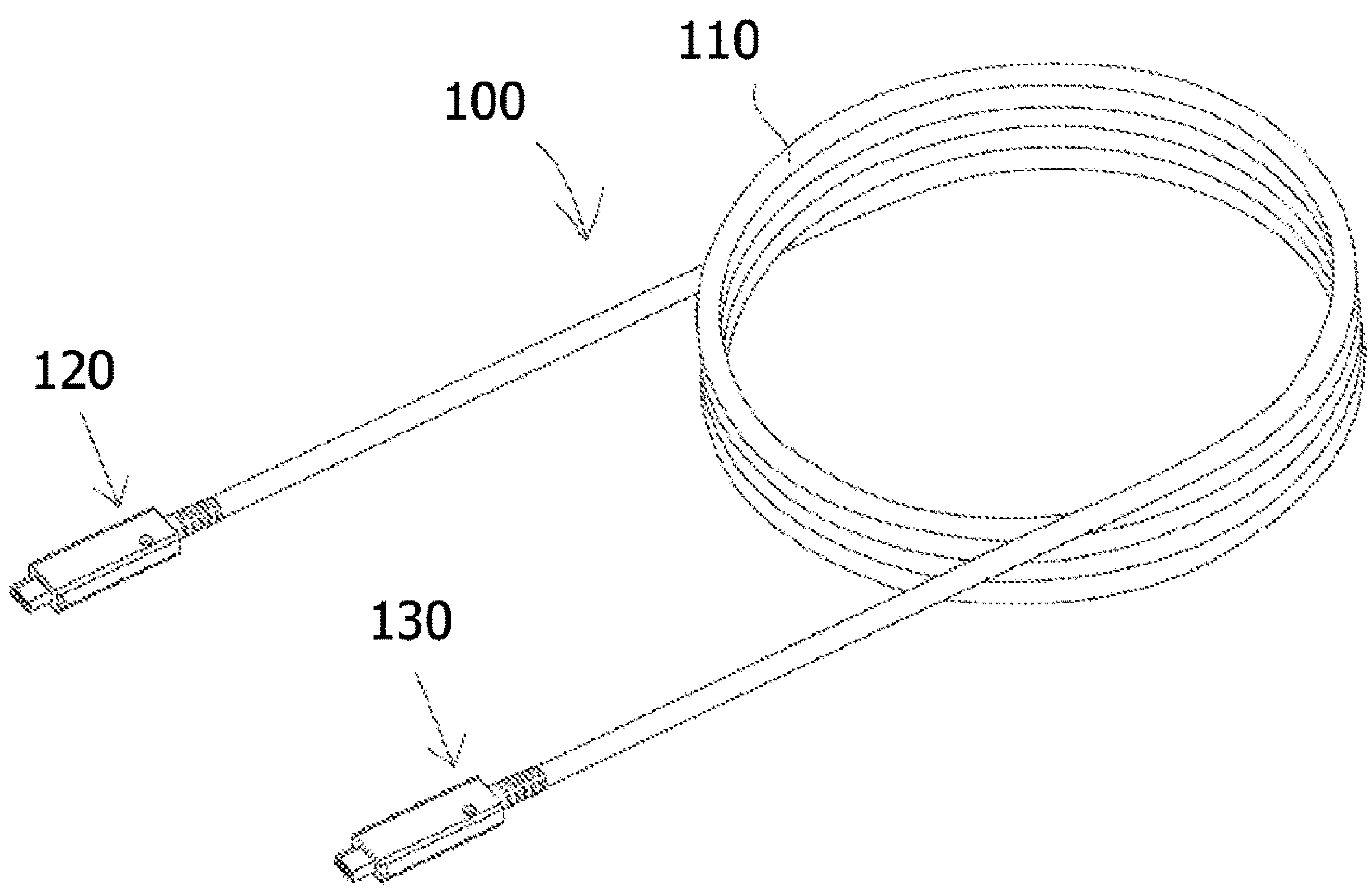


Fig.1

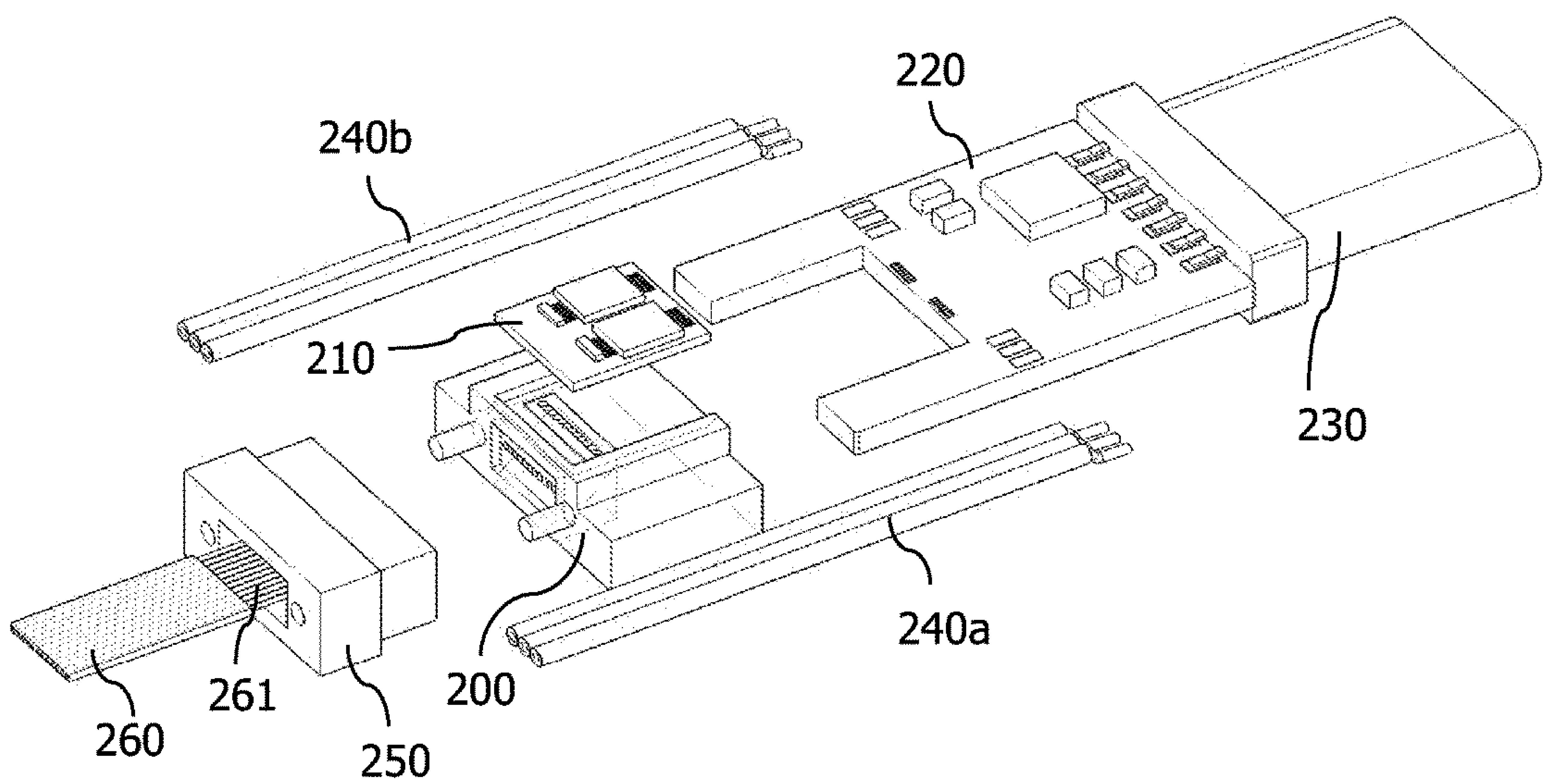
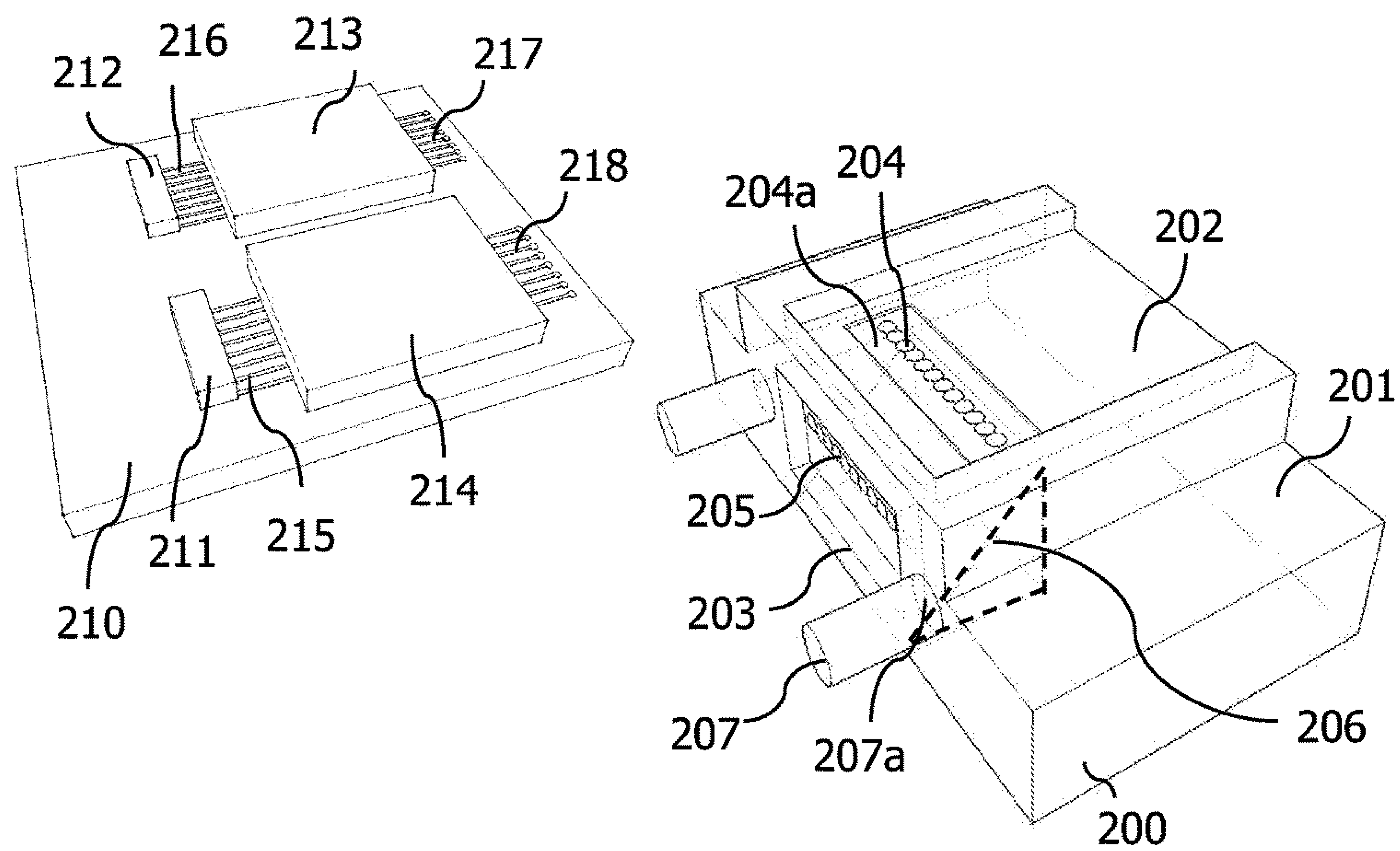


Fig.2


212
216
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204a
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202
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205
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207
207a
206
200

Fig.3

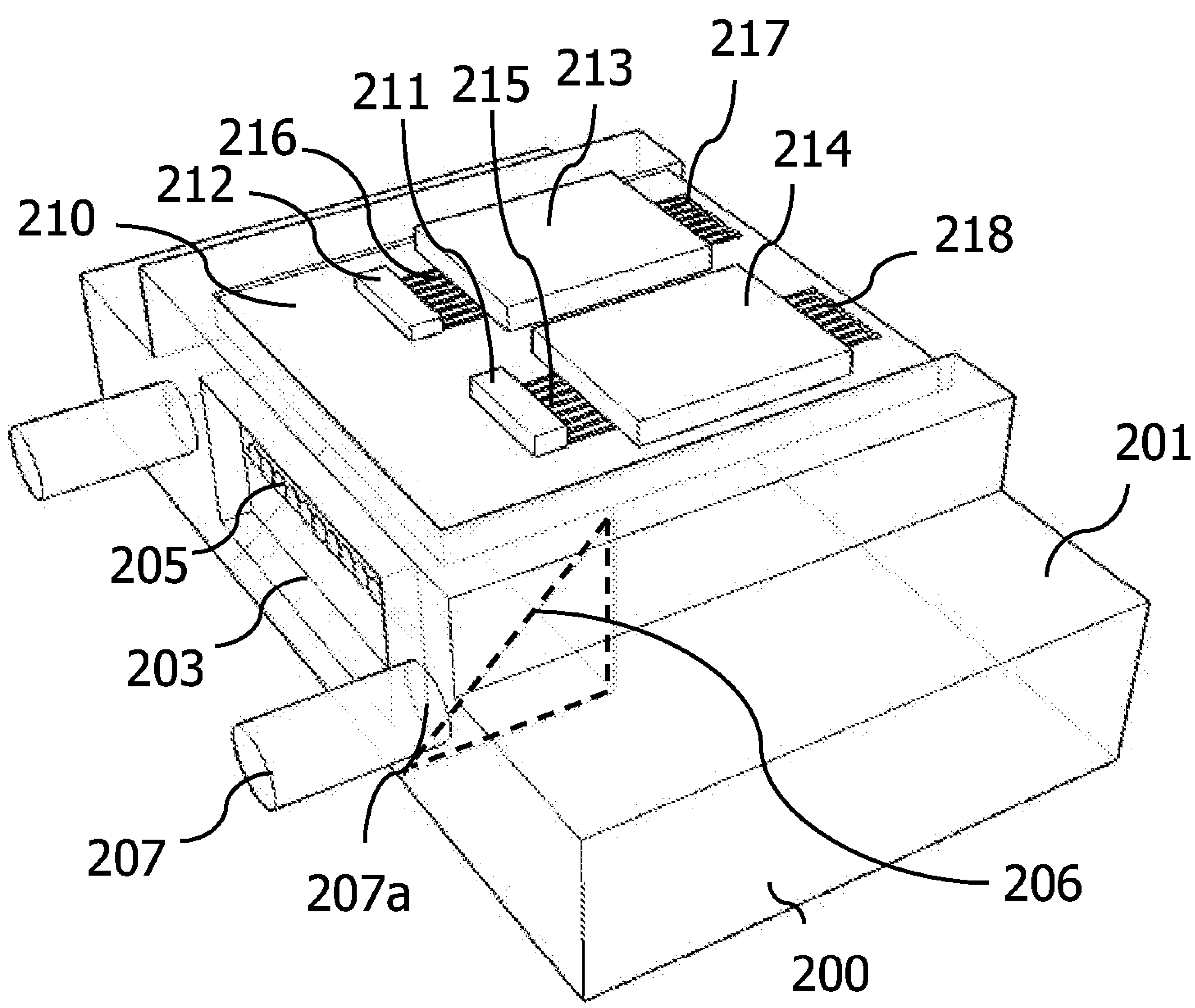

Fig.4

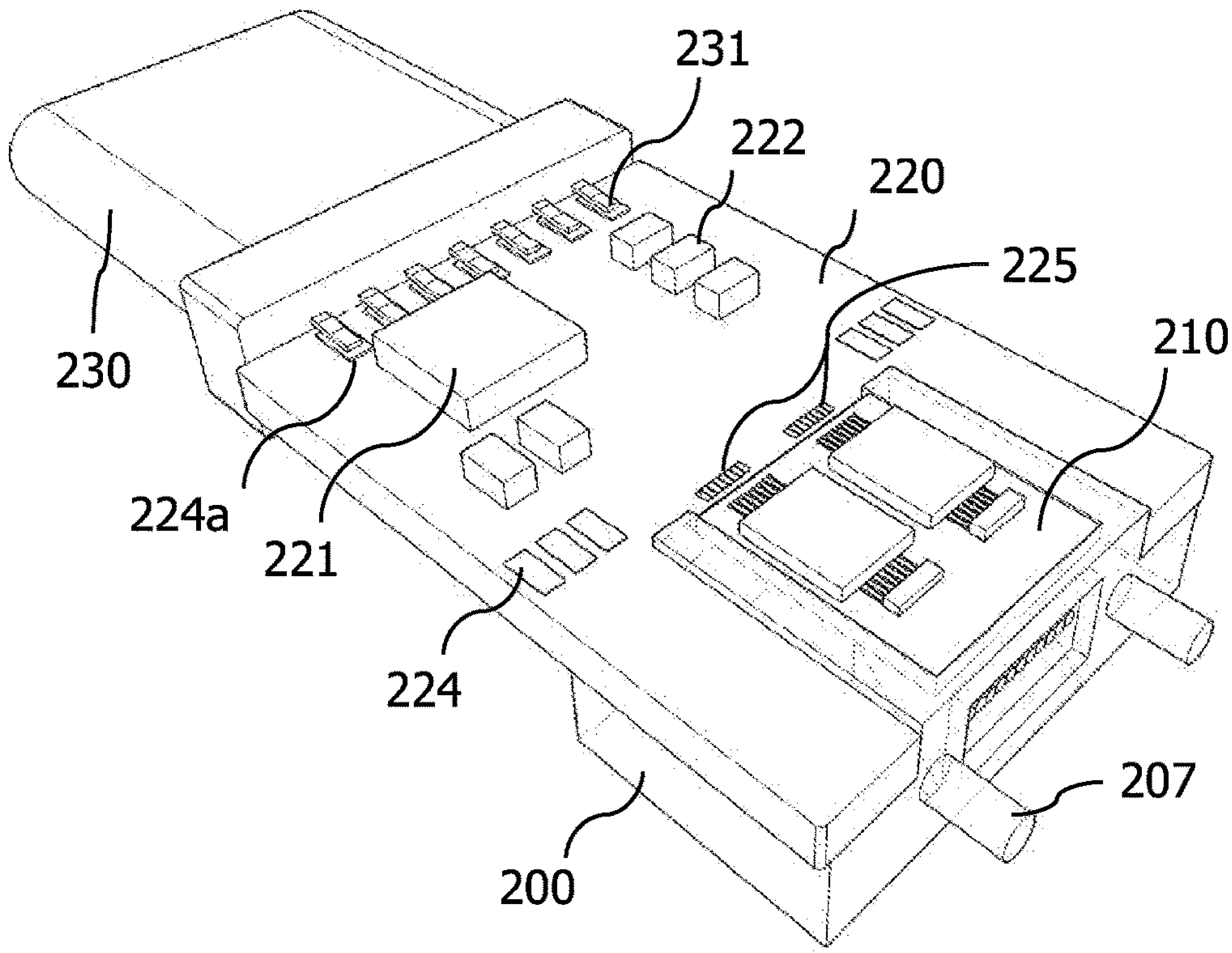

Fig.5

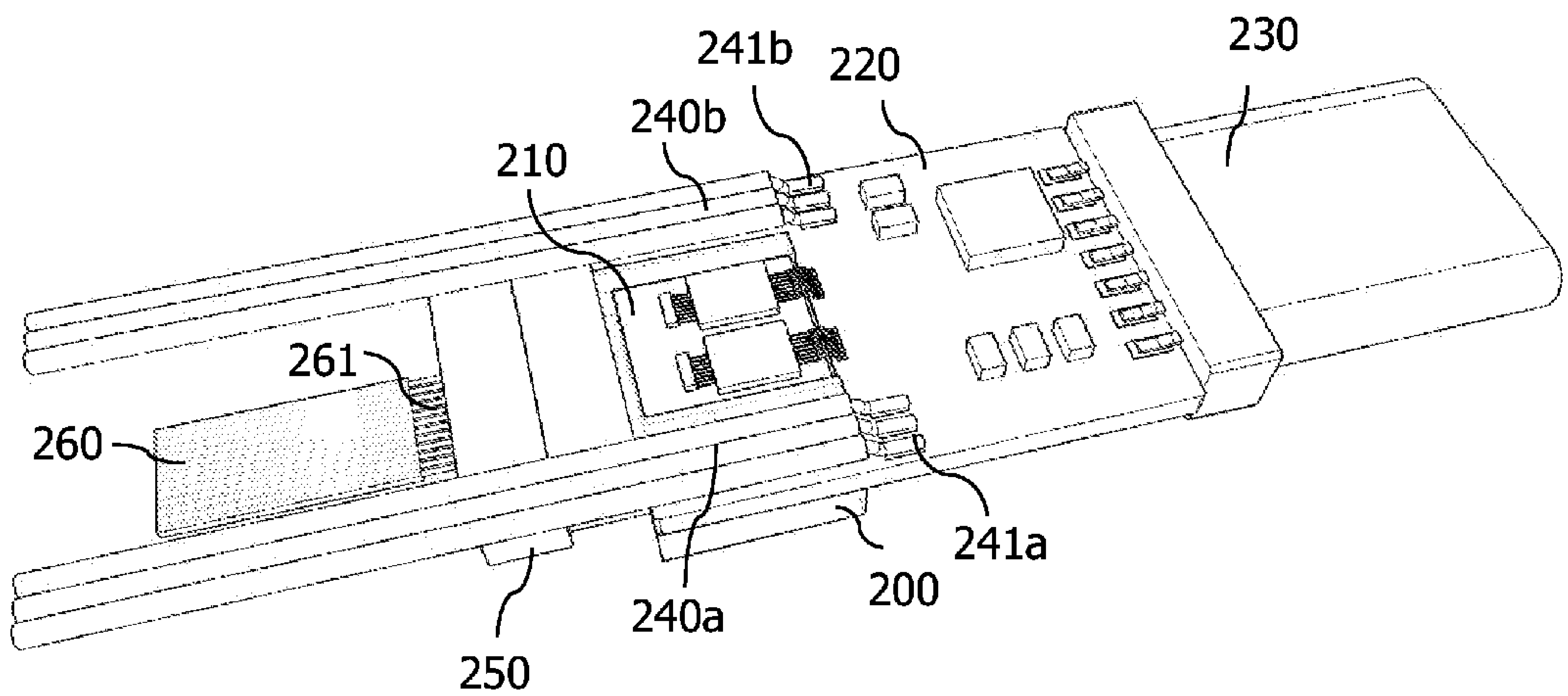

Fig.6

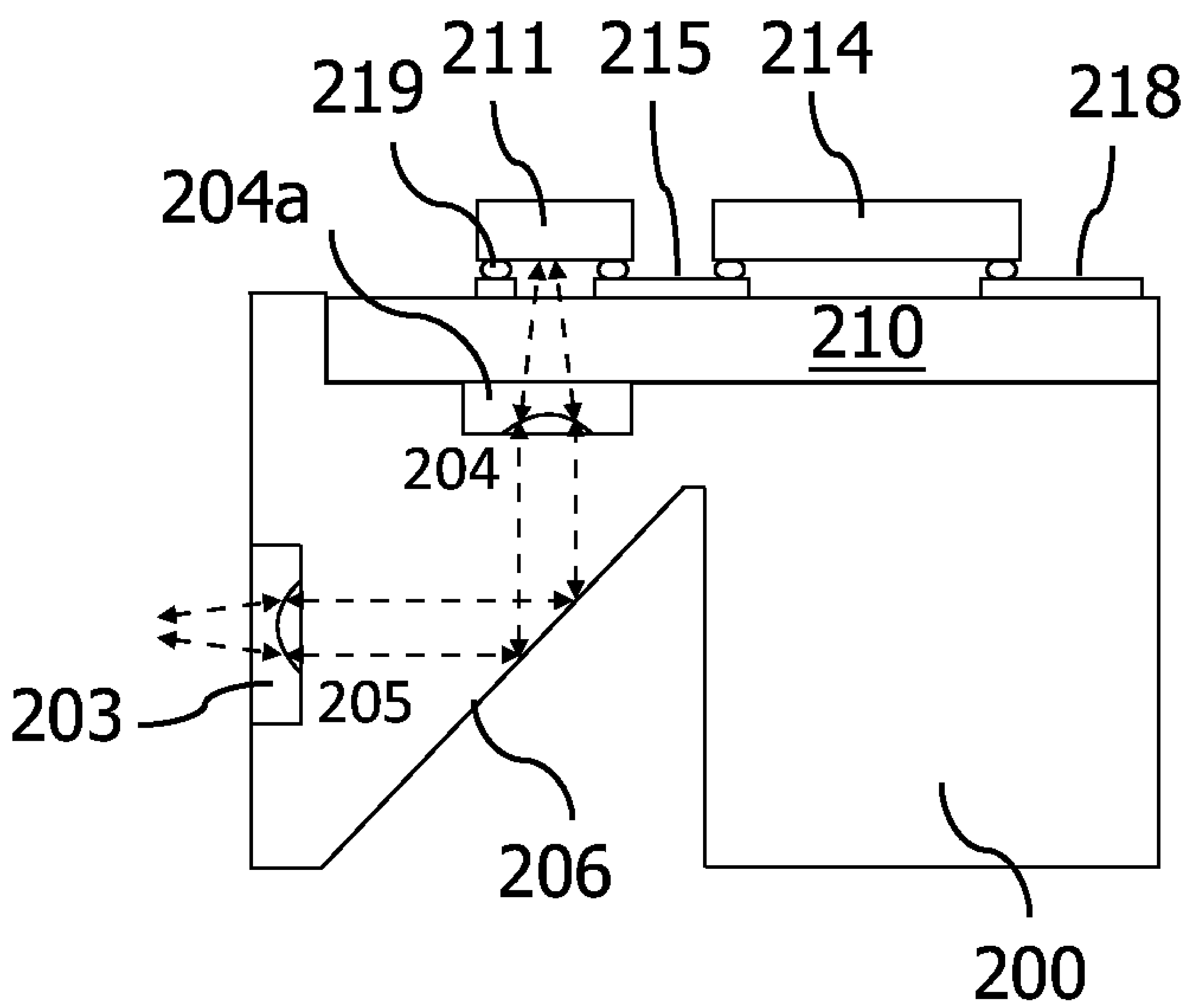

Fig.7

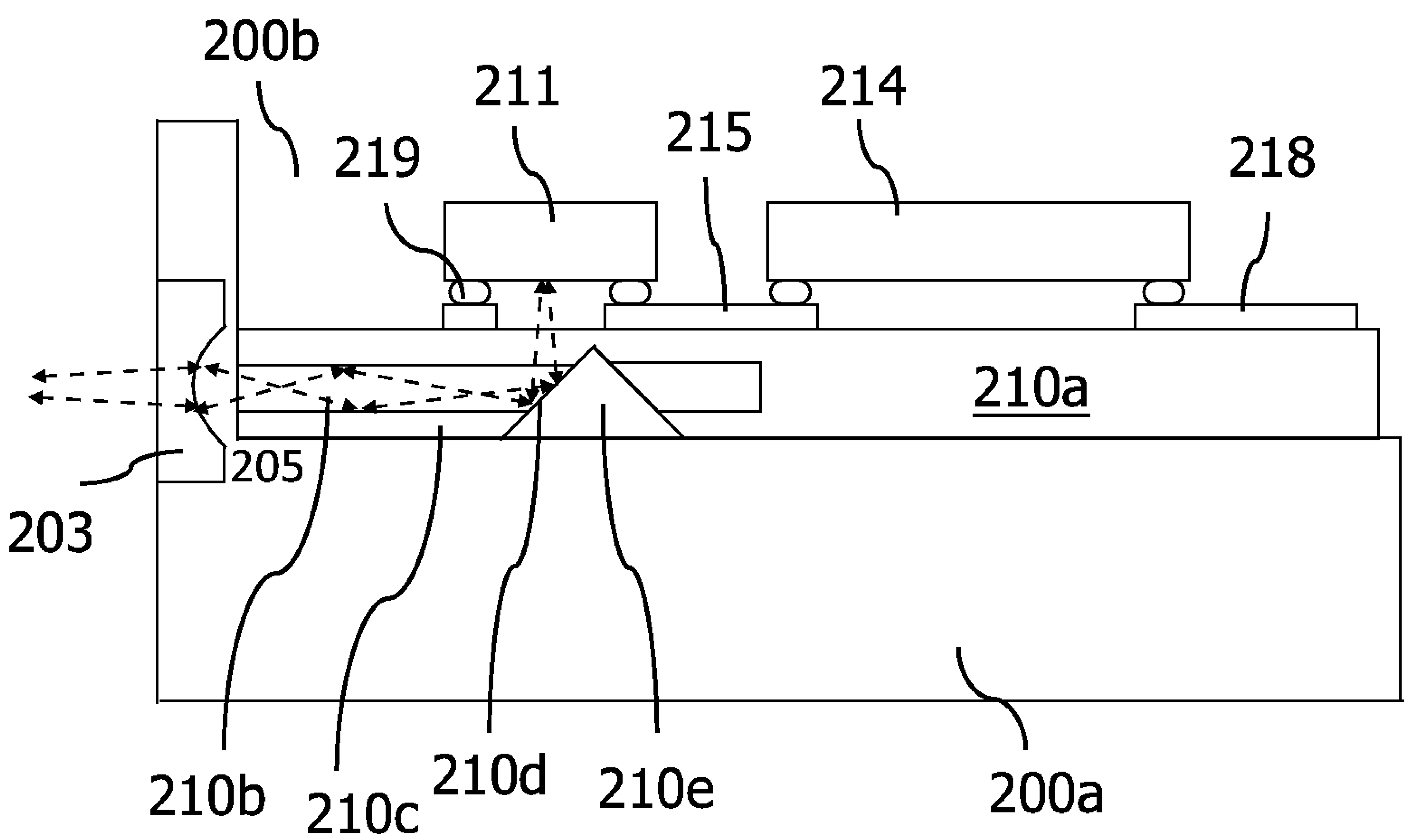

Fig.8

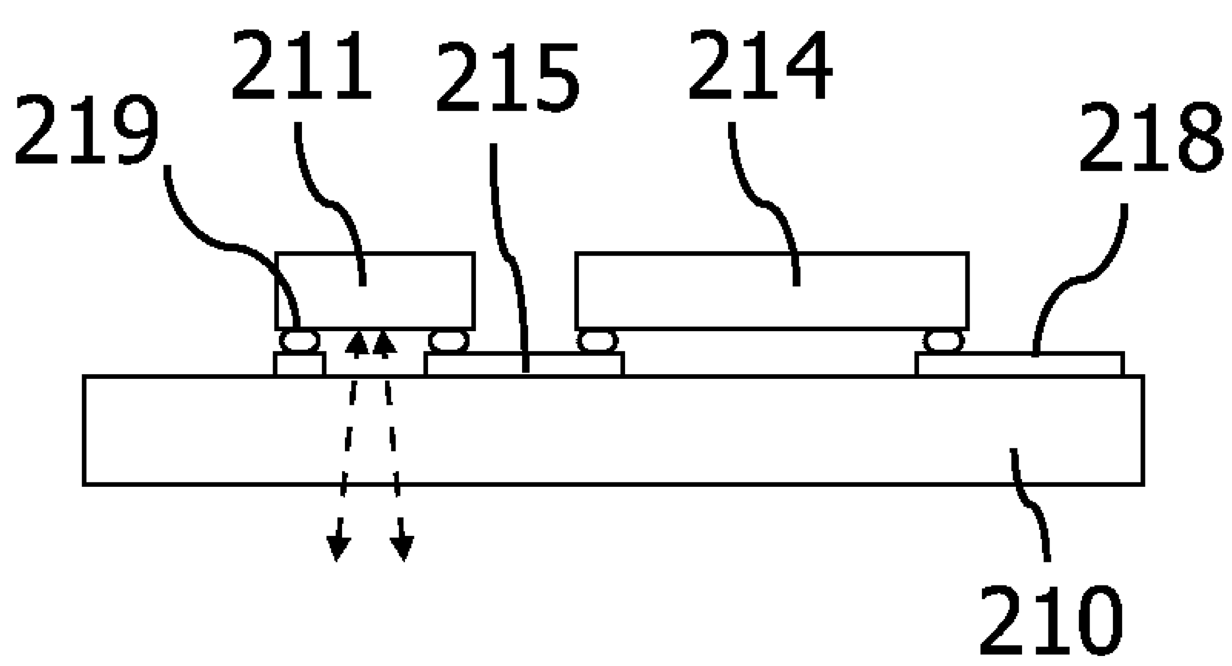

Fig.9a

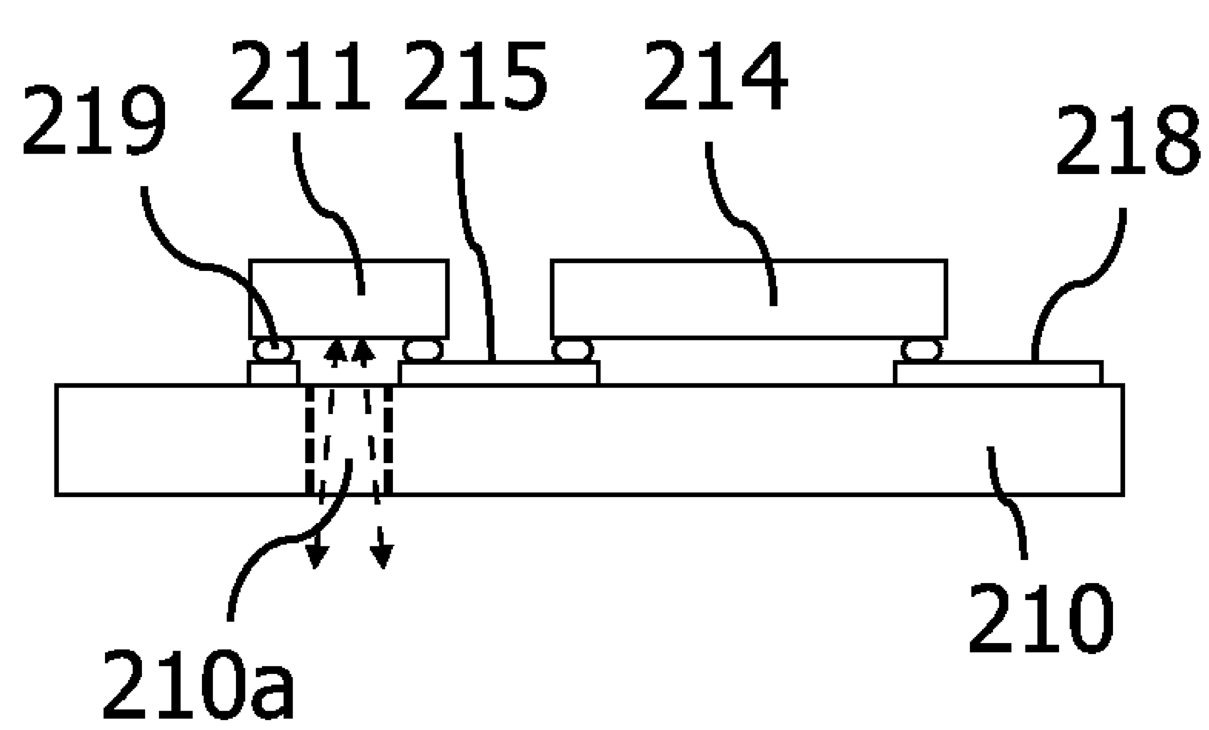

Fig.9b

STRUCTURE OF PHOTOELECTRIC CONVERSION ASSEMBLY HAVING A CIRCUIT BOARD EMBEDDED WITHIN THE CONCAVE PORTION OF AN OPTICAL BENCH

TECHNICAL FIELD

The present invention relates to a photoelectric device, and more particularly, to a photoelectric conversion assembly to provide signal transmission and conversion between the optical devices and electrical devices.

BACKGROUND

Light beams or optical signals are frequently used to transmit digital data between electronic devices, both over long distances and between adjacent circuit boards. A light beam may be modulated as needed to carry data. An optical signal may also be used for other purposes including position or motion sensing, measurement, etc.

Typically, a typical multi-fiber optic connector includes a ferrule assembly supported at a distal end of a connector housing. The ferrule assembly can include a multi-fiber ferrule mounted in a hub. A spring is used to bias the ferrule assembly in a distal direction relative to the connector housing. The multi-fiber ferrule functions to support the end portions of multiple optical fibers. The multi-fiber ferrule has a distal end face at which polished ends of the optical fibers are located. When two multi-fiber optic connectors are interconnected, the distal end faces of the multi-fiber ferrules oppose and are biased toward one another by their respective springs. With the multi-fiber optic connectors connected, their respective optical fibers are coaxially aligned such that the end faces of the optical fibers directly oppose one another. In this way, optical signals can be transmitted from one optical fiber to another optical fiber through the aligned end faces of the optical fibers.

Systems for interconnecting optical fibers typically utilize mating ferrule assemblies to facilitate handling and accurate positioning of the fibers. The optical fibers are secured within a ferrule body, with an end surface of each fiber being positioned generally flush with or slightly protruding from an end face of the ferrule body. The end surfaces or faces of the fibers are then polished to a desired finish. When complementary ferrules assemblies are mated, each optical fiber of a ferrule assembly is coaxially positioned with a mating optical fiber of the other ferrule assembly. In some applications, the end faces of the mating optical fibers physically contact one another in order to effect signal transmission between the mating optical fiber pair. In such applications, various factors may reduce the efficiency of the light transmission between the optical fiber pair.

Consequently, optical technology plays a significant role in modern electronic devices, and many electronic devices employ optical components. Examples of such optical components include optical or light sources such as light emitting diodes and lasers, waveguides, fiber optics, lenses and other optics, photo-detectors and other optical sensors, optically-sensitive semiconductors, and others.

The use of the optical fibers requires photoelectric conversion modules to convert electrical signals to optical signals, or optical signals to electrical signals. Also, the photoelectric conversion modules are attached to be fixed to ends of the optical fibers, or to be attachable to or detachable from ends of the optical fibers.

SUMMARY OF THE INVENTION

In this invention, a photoelectric conversion assembly is proposed. The photoelectric conversion assembly comprises a photoelectric conversion module, a printed circuit board for coupling to the photoelectric conversion module, electrical wires for coupling to the printed circuit board, an optical fiber component for transmitting light, an optical ferrule for engaging with the photoelectric conversion module and the optical fiber component, and a plug for electrically connecting the printed circuit board.

The photoelectric conversion module comprises an interposer, at least one optical element configured on the interposer, an optical bench having a first placement area for the printed circuit board configured thereon and a second placement area for the interposer configured thereon, a first lens array configured under the interposer to align the at least one optical element, a mirror configured under the first lens array, and a second lens array configured left side of the mirror.

According to one aspect, the photoelectric conversion module comprises an interposer with an optical waveguide portion and V-shape trench having a first optical micro-reflection surface and a second optical micro-reflection surface opposite to the first optical micro-reflection surface, at least one optical element configured on the interposer, an optical bench having a first placement area for the printed circuit board configured thereon and a second placement area for the interposer configured thereon, and a lens array configured to align the optical waveguide portion.

According to one aspect, the optical bench has a first concave portion for the first lens array formed thereon and a second concave portion for the second lens array formed thereon. The arrangement orientation of the first lens array is the same as the second lens array. The first lens array, the second lens array and the mirror are embedded into the optical bench. A conductive trace is formed on the interposer to couple the at least one optical element.

According to another aspect, at least one IC is optionally configured on the interposer to couple the conductive trace formed on the interposer.

According to yet another aspect, the printed circuit board is attached on the first placement area of the optical bench by using an adhesive material. The interposer is attached (mounted) on the second placement area of the optical bench by using an adhesive material.

Size of the interposer is less than or equal to that of the second placement area of the optical bench.

The photoelectric conversion assembly further comprises a guide pin for engaging the optical ferrule with the optical bench and the optical fiber component. The printed circuit board has conductive terminal to electrically connect to the electrical wires. A conductive trace is formed on the printed circuit board. The first placement area locates two sides of the optical bench. The interposer has a through hole passing through a top surface of the interposer to a bottom surface of the interposer.

BRIEF DESCRIPTION OF THE DRAWINGS

The components, characteristics and advantages of the present invention may be understood by the detailed descriptions of the preferred embodiments outlined in the specification and the drawings attached:

FIG. **1** illustrates a schematic structural perspective view showing an active optical cable provided with photoelectric conversion module according to an embodiment of the invention;

FIG. **2** illustrates a schematic perspective view showing a photoelectric conversion assembly according to an embodiment of the invention;

FIG. **3** illustrates a perspective view showing an interposer and an optical bench of the photoelectric conversion module according to an embodiment of the invention;

FIG. **4** is a perspective view showing the photoelectric conversion module according to an embodiment of the invention;

FIG. **5** illustrates a perspective view showing a PCB integrated on an optical bench of the photoelectric conversion module according to another embodiment of the invention;

FIG. **6** illustrates the AOC photoelectric conversion assembly according to one embodiment of the invention.

FIG. **7** illustrates a cross-sectional view showing the photoelectric conversion module according to one embodiment of the invention;

FIG. **8** illustrates a cross-sectional view showing the photoelectric conversion module according to another embodiment of the invention;

FIGS. **9***a* and **9***b* illustrate a cross-sectional view showing an interposer according to one embodiment of the invention;

DETAILED DESCRIPTION

Some preferred embodiments of the present invention will now be described in greater detail. However, it should be recognized that the preferred embodiments of the present invention are provided for illustration rather than limiting the present invention. In addition, the present invention can be practiced in a wide range of other embodiments besides those explicitly described, and the scope of the present invention is not expressly limited except as specified in the accompanying claims.

FIG. **1** illustrates a schematic perspective view showing an outer appearance of an active optical cable (AOC) **100**. The active optical cable **100** is composed of a photoelectric composite cable **110**, and a first photoelectric conversion assembly **120** and a second photoelectric conversion assembly **130** which are attached to both ends of the photoelectric composite cable **110**. The active optical cable **100** may be used for unidirectional transmission or bidirectional transmission. The active optical cable **100** may be applied to be as a high speed transmission wire, such as Universal Serial Bus (USB), High-Definition Multimedia Interface (HDMI), Lighting or Thunderbolt interface, for cable line consumer products, or applied to be as a transmission wire, such as storage BUS including Fiber Channel (FC), Serial Attached SCSI (SAS), Peripheral Component Interconnect express (PCIe) or Serial Advanced Technology Attachment (SATA), for photoelectric products or equipment. In an example, active optical cable **100** may be used for connection between digital audio-video (AV) apparatus or equipment. In one embodiment, the first photoelectric conversion assembly **120** is an optical transmitter and the second photoelectric conversion assembly **130** is an optical receiver, for unidirectional transmission. In another embodiment, the first photoelectric conversion assembly **120** is a first optical transceiver and the second photoelectric conversion assembly **130** is a second optical transceiver, for bidirectional transmission. For example, the photoelectric composite cable **110** may be using an optical fiber cable or a hybrid cable depending on various applications. The hybrid cable is composed of optical fiber and electrical wire.

FIG. **2** illustrates a schematic perspective view showing photoelectric conversion assembly according to an embodiment of the invention. The photoelectric conversion assembly comprises a photoelectric conversion component/module, a printed circuit board (PCB) **220**, and a photoelectric composite cable, wherein the photoelectric conversion component/module may be used for unidirectional transmission or bidirectional transmission. The photoelectric conversion component/module may be applied to a high speed transmission interface, such as USB, HDMI, Lighting or Thunderbolt interface, for cable line consumer products, or applied to a transmission interface, such as storage BUS including Fiber Channel (FC), SAS, PCIe or SATA, for photoelectric products or equipment. In one embodiment, the photoelectric conversion module may be as an optical transmitter or an optical receiver, for unidirectional transmission. In another embodiment, the photoelectric conversion module may be as an optical transceiver for bidirectional transmission. In one embodiment, the photoelectric conversion component/module comprises an optical bench **200** and an interposer **210**. In one embodiment, photoelectric composite cable is a hybrid cable including an optical fiber component **260** and electrical wires **240***a* and **240***b*.The photoelectric conversion assembly further comprises an optical ferrule **250** for engaging/connecting with the optical bench **200** and the optical fiber component **260**, and a plug **230** for electrically connecting the printed circuit board (PCB) **220**.

In one embodiment, optical fiber component **260** is an optical ribbon fiber or bundle fiber. The optical ribbon fiber **260** has optical fibers **261** inserted into receiving holes, bores or grooves of the optical ferrule **250** for electrically coupling to optical elements configured on the interposer **210**. The optical fibers **261** are inserted into the optical ferrule **250** for coupling/connecting (engaging) to the photoelectric conversion module. The receiving holes or bores are generally cylindrical. For example, the optical fibers **261** are multimode fibers or single mode fiber. The optical fibers **261** aligned in series are multimode fibers that are included in the optical ribbon fiber **260**. Each of the optical fibers **261** has a core formed at a center thereof, a cladding surrounding the core, and a coating layer coated on an outer surface of the cladding in order to protect the core and the cladding, wherein reflective index (n) of the core is 1.35~1.70 and reflective index of the cladding is 1.35~1.70.The optical fibers **261** are for example 50/125, 62.5/125, or 80/125 graded index (GI) multimode fibers.

FIG. **3** illustrates a perspective view showing an interposer and an optical bench of the photoelectric conversion module according to an embodiment of the invention. In one embodiment, optical elements are configured on the interposer **210**. For example, a light source chip **212** and a light receiving element **211** are configured on the interposer **210**. In one embodiment, a light source chip, a photo diode, a photo detector chip or a photosensitive chip is configured on the interposer **210**. In one embodiment, ICs **213**, **214** are configured on the interposer **210**, for example a driver integrated circuit (IC), a control IC or a trans-impedance amplifier (TIA) chip, or others active components, configured on the interposer **210**. Moreover, passive electronic components may be configured on the interposer **210**. In another embodiment, ICs, passive electronic components may be configured on the printed circuit board **220**. Conductive trace **218**, **217**, **216** and **215** are configured on the interposer **210**. Conductive trace **218**, **217**, **216** and **215** may be formed by an identical manufacturing process. In one example, the light source chip **212**, the light receiving element **211** and ICs **213**, **214** are packaged on the interposer **210** by a flip-chip mounting process. The conductive trace **218**, **217** on the interposer **210** may be electrically connected to outer circuits (conductive trace **225** on the PCB **220**, shown in FIG. **5**), for example by wire bonding or directly electrically connecting. The conductive trace **216** on the interposer **210** is electrically connected to the light source chip **212** and ICs **213**, and the conductive trace **215** on the interposer **210** is electrically connected to the light receiving element **211** and ICs **214**. Material of the interposer **210** comprises silicon, silica, ceramic, or dielectric material, or the interposer **210** is flexible print circuit (FPC) as a substrate. In one embodiment, the optical bench **200** is fabricated by using an injection molding process, such as plastic injection molding process, to form a first placement area (platform) **201**, a second placement area (platform) **202**, and lens array **204**, **205**. The first placement area (platform) **201** is used for supporting the PCB **220**, and the second placement area (platform) **202** is used for supporting the interposer **210**. In one embodiment, the first placement area **201** locates two sides of the optical bench **200** with first concave portion, and the second placement area (platform) **202** is formed to be U-shape or mouth font with a second concave portion. In one embodiment, the lens array **204**, **205** are used for light focusing or collimating. The lens array **204**, **205** may be used to improve efficiency of optical usage and increase allowable value of optical package.

Size of the interposer **210** is less than or equal to that of the second placement area **202** of the optical bench **200**.

The photoelectric conversion module has the interposer **210** and the optical bench **200** with doubles sides lens array **204**, **205**. In one embodiment, arrangement orientation of the lens array **204** is the same as the lens array **205**. The optical bench **200** has a concave portion **202** for the interposer **210** configured/fixed thereon, and the interposer **210** is disposed within the concave portion **202**. The optical bench **200** has a third concave portion **203** which locates front side of the optical bench **200** for the lens array **205** formed thereon. In one embodiment, the lens array **204**, **205** and the mirror **206** are embedded (integrated) into the optical bench **200**. A mirror or reflector **206** is integrated into the optical bench **200**.

The mirror or reflector **206** is passively for optical signal excited by the light source chip **212** to be non-coplanar turning (optical reflection), and the optical signal is guided to the external optical transmission medium, such as optical fibers **261**. Conversely, optical signals through an external optical transmission medium (optical fibers **261**) are non-coplanar turning by the mirror **206** to guide the optical signals to be received by the light receiving element **211**. The mirror **206** can be fabricated to directly integrate into the optical bench **200** or the interposer **210**.

The interposer **210** may be attached on the second concave portion **202** of the optical bench **200** by using an adhesive material, such as epoxy, shown in FIG. **4**. The PCB **220** may be further attached on the first concave portion **201** of the optical bench **200** by using an adhesive material, such as epoxy, shown in FIG. **5**. As shown in FIG. **5**, the PCB **220** has electrical wire soldering pads **224**, pads **224*a*** and wire bond pads **225** formed thereon. The pads **224*a*** are used to electrically connect to the plug **230**. The conductive terminal **231** of the plug **230** may be soldering on the pads **224*a*** of the PCB **220**, shown in FIG. **6**. The electrical wire soldering pads **224** are used for electrically connecting the electrical wires **240*a*** and **240*b***.The conductive terminal of the electrical wires **240*a*** and **240*b*** may be soldering on the electrical wire soldering pads **224** of the PCB **220**, shown in FIG. **6**. The wire bond pads **225** are used for electrically connecting the conductive trace (metal trace) **217** and **218** on the interposer **210**, for example electrically connecting by a wire bonding process. In one embodiment, the PCB **220** has at least one IC **221** and at least one passive component **222** configured thereon.

In one embodiment, the optical ferrule **250** includes a fiber connecting portion and an optical bench connecting portion for connecting the optical fiber component **260** and the optical bench **200** respectively, shown in FIG. **6**. The optical ferrule **250** may be as a joint of external optical transmission medium (optical fiber). The receiving holes, bores or grooves extend through from the front surface of the fiber connecting portion to the rear surface of the optical bench connecting portion. In one embodiment, the fiber connecting portion and the optical bench connecting portion may be integrally fabricated.

The optical bench connecting portion includes a mating recess (guide holes) formed therein for receiving the guide pins **207**. The optical bench **200** also includes the guide pins **207**. As depicted in FIG. **3**, a mating portion (guide pins) **207** may be engaged into the mating recess (guide holes) of the optical bench connecting portion. In the depicted FIG. **3**, the guide pins **207** is located adjacent sides of the lens array **205** of the optical bench **200**. In one embodiment, the guide holes extend through the optical bench connecting portion, or through the front surface of the fiber connecting portion to the rear surface of the optical bench connecting portion. The guide pins **207** of the optical bench **200** aligns to the mating recess (guide holes) of the optical bench connecting portion to facilitate aligning and connecting the optical bench connecting portion of the optical ferrule **250** and the optical bench **200** of the photoelectric conversion module when the guide pins **207** matches the mating recess (guide holes) of the optical bench connecting portion. In one embodiment, the guide pin **207** and the optical bench **200** are integrally manufactured. In another embodiment, the guide pin **207** and the optical ferrule **250** are integrally manufactured, and the optical bench **200** has guide holes for engaging with the optical ferrule **250**. In one embodiment, the optical bench **200** is fabricated by using an injection molding process, such as plastic injection molding process, to form a first placement area (platform) **201**, a second placement area (platform) **202**, lens array **204**, **205** and the guide pin **207**.

In one embodiment, length of the multi-channel fiber connecting portion is less 10 mm (minimeters), thickness of the multi-channel fiber connecting portion is less 3 mm, and width of the multi-channel fiber connecting portion is less 5 mm. Thus, the multi-channel fiber connecting portion of the invention has smaller size than prior arts.

As shown in FIG. **7**, the lens array **204** is formed on the bottom surface of a fourth concave portion **204*a*** under the bottom surface of the concave portion **202** of the optical bench **200**, aligning optical elements (light source chip **212** and light receiving element **211**) on the interposer **210** when the interposer **210** is attached on the second concave portion **202** of the optical bench **200**. The lens array **204** locates under the interposer **210**. The lens array **205** is formed on (under) the bottom surface of the third concave portion **203** of the optical bench **200**. The mirror **206** locates under the lens array **204** and locates right side of the lens array **205**. The lens array **204** may be used to make divergent light emitted by the light source chip **212** to form an approximately collimated light, and the emitted light is focusing by the lens array **205** after reflecting by the mirror **206**. The light source chip **212** emits light forward to the interposer **210** and passing through the interposer **210** and the lens array **204**, and reflecting by the mirror **206** to the lens array **205** for focusing the emitted light and propagating to the external transmission medium (optical fibers **261**), shown in FIG. **7**. On the other hand, light created by the external device feeds into the optical fibers **261**, passing through the lens array **205** to form an approximately collimated light and reflecting by the mirror **206** to pass through the lens array **204** for focusing light and passing through the interposer **210**, and thereby receiving the inputted light by the light receiving element **211**, shown in FIG. **7**.

The rear ends of the plural optical fibers **261** are fixed to an end of the optical bench connecting portion of the optical ferrule **250**. The photoelectric conversion module has a function of converting an optical signal (via the plural optical fibers **261**) from external electrical apparatus or equipment into an electrical signal, or transmitting an optical signal to the external electrical apparatus or equipment via the plural optical fibers **261**.

In one embodiment, ICs are, for example a driver integrated circuit (IC), a control IC or a trans-impedance amplifier (TIA) chip, or others active components, configured on the interposer. The driver IC may be used to drive the light source chip (such as optoelectronic device) for emitting light.

In another embodiment, the photoelectric conversion module has the interposer **210***a* and the optical bench **200***a*.The interposer **210***a* has an optical waveguide portion **210***b* and a mirror **210***d*, and the optical bench **200***a* has a single lens array **205**, shown in FIG. **8**. The optical bench **200***a* has a concave portion **200***b* for the interposer **210***a* and the PCB configured/fixed thereon, and the concave portion **200***b* locates upper side of the interposer **210***a*. The optical bench **200***a* has another concave portion **203** which locates front side of the optical bench **200***a*. The optical waveguide portion and the mirror **210***d* are integrated into the interposer **210***a*. The optical waveguide portion is made of core **210***b* and clad **210***c*, wherein reflective index of the core **210***b* is larger than that of the clad **210***c*.The core **210***b* is made of a flexible material, such as polymer. The clad **210***c* is covering over the core **210***b*. The optical waveguide portion is used as an optical waveguide. The interposer **210***a* has a concave structure **210***e*, such as V-shape trench, with an optical micro-reflection surface (mirror) **210***d* at one side of (within) V-shape trench **210***e* and rear side of the optical waveguide portion, shown in FIG. **8**. The mirror **210***d* locates under the light source chip **211** and photo diode chip (PD chip) **212** for reflecting optical signals from the light source chip **211** or the optical fibers **261**. The mirror **210***d* has a specified angle (such as 45 degree angle or other degree angle). V-shape trench **210***e* of the interposer **210***a* has a specified depth (vertical thickness). The first end of the V-shape trench **210***e* of the interposer **210***a* forms a reflection surface. The V-shape trench **210***e* has a first slant plane and a second slant plane, wherein the first slant plane is opposite to the second slant plane. Vertical thickness of the V-shape trench **210***e* is larger than that of the core **210***b* of the optical waveguide portion, and the V-shape trench **210***e* is passing through the core **210***b* of the optical waveguide portion. V-shape trench **210***e* may be formed by an imprinting process, a wedge cutting process or a laser cutting process. In another example, V-shape trench **210***e* may be formed by a photolithography process and an etching process. Light source chip **211** and photo diode chip (PD chip) **212** are packaged on the interposer **210***a*.The ICs **213**, **214** may be electrically connected to the external devices via the metal trace **161**, **160** by wire bond or flip board mounting.

In this embodiment, the interposer **210***a* has waveguide function used for guiding light. The interposer **210***a* comprises an optical waveguide portion, such as polymer, embedded into the interposer **210***a*. In one embodiment, the interposer **210***a* is a flexible substrate.

The core **210***b* of the optical waveguide portion aligns to the lens array **205** for optical communication, shown in FIG. **8**. Such structure may receive and transmit optical signal through the optical waveguide portion. Light created by the light source chip **211** may be reflected via the optical micro-reflection surface **210***d* at one side of the optical waveguide portion. The core **210***b* of the optical waveguide portion is allowable for optical path penetrating therein, for facilitating light emitted from the light source chip **211** or coming from external devices passing through therein. The light source chip **211** is capable of emitting visible and invisible light. The light source chip **211** is for example a laser, infrared light or a light emitting diode (LED). Infrared light is in infrared band, which can be emitted by laser or LED.

For example, the light source chip **211** and the photo detector **212** are arranged in the vicinity of the optical micro-reflection surface **210***d*. Therefore, optical signal emitted by the light source chip **211** is reflected by the optical micro-reflection surface **210***d* of the V-shape trench **210***e* and then passing through the core **210***b* of the flexible waveguide portion.

Material and thickness of the flexible waveguide portion may be selected, based-on requirements for practical applications. For example, material of the flexible waveguide portion includes polymer material, dielectric material, such as polyimide.

The interposer **210***a* may be attached on the concave portion **200***b* of the optical bench **200***a* by using an adhesive material, such as epoxy, shown in FIG. **7** and FIG. **8**. ICs **213**, **214** are electrically connected to the external apparatus or equipment for signal connection via the conductive trace **217**, **218** of the interposer **210***a*. V-shape trench **210***e* faces the top surface of the optical bench **200***a* within the concave portion **200***b* when the interposer **210***a* is attached on the optical bench **200***a*.

The optical bench combines with the interposer having flexible waveguide (optical waveguide portion) for optical communication. Such structure may receive and transmit optical signal through the flexible waveguide. Light created by the light source may be reflected via the optical micro-reflection surface at one side of the flexible substrate.

As noted above, the flexible waveguide (optical waveguide portion) of the flexible substrate includes an under cladding layer, a core and an over cladding layer. Materials of the under cladding layer, the core and the over cladding layer are not specifically limited, and it is possible to used, e.g., an acrylic resin, an epoxy resin and a polyimide resin, etc.

The optical micro-reflection surface is arranged on an optical path extending between the light source (photoelectric conversion array element) **211** and the core to bend the optical path 90 degree.

The interposer **210** is allowable for optical path penetrating therein, for facilitating light emitted from the light source chip **212** or coming from external devices passing through therein, shown in FIG. **9***a*. In another embodiment, interposer **210** has a through hole **210***a* passing through a top surface of the interposer **210** to a bottom surface of the interposer **210** allowable for optical path penetrating therein, for facilitating light emitted from the light source chip **212** or coming from external devices passing through therein, shown in FIG. **9***b*. Conductive bump **219** (for example solder bump, metal bump or gold bump) may be formed on the conductive trace **215**, **216**, **217** and **218** for coupling to the light source chip **212**, the light receiving element **211** and the ICs **213**, **214**. The light source chip **212** is capable of emitting visible and invisible light. The light source chip **212** is for example a laser, infrared light or a light emitting diode (LED) Infrared light is in infrared band, which can be emitted by laser or LED.

The conductive trace on the interposer may be electrically connected to ICs or the circuit board by wire bond or flip board for signal connection.

As will be understood by persons skilled in the art, the foregoing preferred embodiment of the present invention illustrates the present invention rather than limiting the present invention. Having described the invention in connection with a preferred embodiment, modifications will be suggested to those skilled in the art. Thus, the invention is not to be limited to this embodiment, but rather the invention is intended to cover various modifications and similar arrangements included within the spirit and scope of the appended claims, the scope of which should be accorded the broadest interpretation, thereby encompassing all such modifications and similar structures. While the preferred embodiment of the invention has been illustrated and described, it will be appreciated that various changes can be made without departing from the spirit and scope of the invention.

What is claimed is:

1. A structure of photoelectric conversion assembly, comprising:

a photoelectric conversion module;

a printed circuit board for coupling to said photoelectric conversion module;

electrical wires for coupling to said printed circuit board;

an optical fiber component for transmitting light;

an optical ferrule for engaging with said photoelectric conversion module and said optical fiber component; and

a plug for electrically connecting said printed circuit board;

wherein structure of said photoelectric conversion module comprises:

a circuit board having conductive trace formed thereon;

at least one optical element flip-chip mounted on said circuit board and coupled to said conductive trace on said circuit board;

an optical bench having a first concave portion and a second concave portion, wherein front side of said printed circuit board is disposed on said first concave portion at two sides of said optical bench, and said circuit board is embedded within said second concave portion of said optical bench to reduce height of said structure of photoelectric conversion assembly; and

wire bond pads of said printed circuit board are electrically connected to said conductive trace of said circuit board by wire bonding.

2. The structure of claim **1**, wherein said photoelectric conversion module further comprises:

a first lens array configured under said circuit board to align said at least one optical element;

a mirror configured under said first lens array; and

a second lens array configured left side of said mirror.

3. The structure of claim **1**, wherein said circuit board has a through hole passing through a top surface of said circuit board to a bottom surface of said circuit board.

4. The structure of claim **2**, wherein said circuit board is attached on said second concave portion of said optical bench by using an adhesive material.

5. The structure of claim **2**, wherein arrangement orientation of said first lens array is the same as said second lens array.

6. The structure of claim **2**, wherein said first lens array, said second lens array and said mirror are embedded into said optical bench.

7. The structure of claim **2**, wherein said at least one optical element is a light source chip, a photo diode chip, a photo detector chip or a photosensitive chip.

8. The structure of claim **2**, further comprising a conductive trace formed on said circuit board to couple said at least one optical element.

9. The structure of claim **2**, further comprising at least one IC formed on said circuit board.

10. The structure of claim **2**, wherein a size of said circuit board is less than or equal to that of said second concave portion of said optical bench.

11. The structure of claim **2**, further comprising a guide pin for engaging said optical ferrule with said optical bench.

12. The structure of claim **2**, wherein said circuit board has a through hole passing through a top surface of said circuit board to a bottom surface of said circuit board.

13. The structure of claim **1**, wherein

said circuit board further includes an optical waveguide portion and V-shape trench;

and

wherein said optical bench includes a lens array configured to align said optical waveguide portion.

14. The structure of claim **13**, further comprising at least one IC formed on said circuit board.

15. The structure of claim **13**, wherein said circuit board is attached on said second concave portion of said optical bench by using an adhesive material.

16. The structure of claim **15**, wherein a size of said circuit board is less than or equal to that of said second concave portion of said optical bench.

17. The structure of claim **13**, wherein said at least one optical element is a light source chip, a photo diode chip, a photo detector chip or a photosensitive chip.

18. The structure of claim **13**, further comprising a conductive trace formed on said circuit board to couple said at least one optical element.

19. The structure of claim **13**, further comprising a guide pin for engaging said optical ferrule with said optical bench.

20. The structure of claim **13**, wherein a size of said circuit board is less than or equal to that of said second concave portion of said optical bench.

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